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### The Literature of EOH II. The Scientific Research Paper

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## Editorial

# The Literature of EOH II. The Scientific Research Paper

Throughout its long history, the original research paper has served researchers well in science. However, one needs to recognize that a scientific research paper is a literary device with its own conventions. These conventions are understood by author, reviewer, editor, and reader in science but not necessarily by scientific outsiders, including most lawyers and other laypeople.

The modern scientific research paper in which the author describes an original contribution has evolved from letters written by individual investigators to the Royal Society (in Britain) or the Royal Academy (in France) and later the American Philosophical Society. They were sent to society meetings by corresponding members who could not make the trip to be read aloud and included in summaries of the meetings (*proceedings*).

These letters put the author's experiment in context, described the approach, described the specific method developed (there were no standardized methods back then for almost any scientific undertaking), and described and discussed the results. This was the beginning of our standard format of Introduction, Methods, Results, Conclusions, and Discussion. The letters from these corresponding members were usually long and often reported as much news as scientific content because the audience was small and intimate and the correspondents were distant friends. The long-windedness of some of these letters presumably gave rise to the Abstract.

A scientific research paper exists so that the author can present a finding and describe a line of investigation. The introduction is hardly ever a chronologically accurate report on the events leading up to the work or the thought process that gave rise to the study. Even when written as if it were, it is not really a historical record of the literal sequence of events. The Introduction rarely records the sometimes messy path by which the examiner arrived at the final, successful experiment: the reagents that did not work, the essential preconditions worked out by trial and error, why the first runs had to be discarded because someone failed to calibrate the spectrophotometer, the inspiration that came while the author gazed into a bowl of cornflakes at breakfast. With

a few showy exceptions that make good stories but bad scientific history (such as the apocryphal story of Kekule's dream of serpents biting one another's tails, which supposedly gave rise to his idea for the structure of benzene), other investigators do not care about such things. They want to know what worked and what was found.

So the original contributions article developed stereotypically; it begins with a connection to previous work, presents the present work, and then ends with a connection to work proposed for the future. The Introduction is like a hook, or piece of Velcro®, connecting the fabric of the work to the earlier literature. It is a device to lay out the essential context of the study, describing in abbreviated form what issues or concerns or previous findings preceded the study and why the study was worth doing. The Discussion is the corresponding hook, or dangling piece of Velcro®, available to connect the work to the future. This is done via the author's interpretation of the meaning of the work, description of its limitations, and, often, proposals of new approaches. Thus, the Discussion section is more than a place to put the universal statement that "more research is needed." It is there to justify the research and serves as a hook for the Introduction of the next article in the series.

The standardized format and narrative structure of the research paper has another benefit: It compensates for the limitations of many poor writers by giving them a framework and making it more convenient for the reader to find essential information. One good development has been the structured abstract in the medical literature.

As noted, the research paper began historically as a description of a line of investigation. Now, researchers base scientific articles on single studies or experiments, usually one per article. Given limits on manuscript length, it is often difficult to report a single extensive or complicated study in just one manuscript. We therefore are seeing an increasing number of reports from large studies divided into multiple manuscripts, often with a single methodological paper to which the others refer. This is fine if they can be published together, or as a series, in one journal and are easily linked through indexing, but few journals do this anymore. In the

future, perhaps improving information technologies will facilitate a relational reading of the literature, making it much easier to see the connection among different contributions.

Whenever possible, the single original contribution with comprehensive data on a single study or experiment remains the ideal, for reasons of efficiency, coherency, and accessibility; however, there are many legitimate reasons to depart from this ideal. When a derivative research publication is justified on the basis of major findings or to elaborate on implications for a special readership, it should always be clear why the second article is required and where the data can be found in the original source article.

Scientists in the same field read articles carefully to evaluate and compare methods and might even replicate the studies being reported. However, most people searching the literature are interested in the findings, not the study or experimental design. Their purpose in reading the methods section is, at best, to assure themselves that the methodology was valid. Most articles that we save (in our reprint files or memory) are remembered for a particular finding or useful bit of information, not as a totality. This means that an article in which the author describes a process is usually read to access a fact.

Although it would be ideal for scientists to be versatile enough to access one interdisciplinary world literature and to read each contribution carefully and with full understanding of the methodology and context, this is not the reality. If an article is published in an unfamiliar journal and uses unfamiliar jargon, it is likely to be missed or underappreciated.

A common misconception is that a scientific research paper should be completely self-contained and comprehensive. But why? The work described in a research paper cannot ever be self-contained; every experiment or study has a context beyond the immediate scope of the work. In the past, research papers in the proceedings of the academies presented the results of years of work and were summaries of many related studies. (This is still common in certain scientific fields, such as physics, where the literature is considered archival rather than a living reflection of current work in the field.)

The readers must either connect the proverbial dots among the studies in a field or depend on someone to review the literature and do it for them. I will discuss review articles in my next editorial in this series.

Scientists write articles for different reasons than they read them. Once we accept this, it becomes easier to imagine ways in which the process of scientific publishing can be improved. The modern scientific research paper will evolve further, as it has in the past.

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Editor in Chief

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